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Hansen, Jesper; Larsen, Flemming Holm

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## A SPHERICAL NEAR-FIELD ANTENNA TEST FACILITY

Jesper E. Hansen and Flemming Holm Larsen  
Electromagnetics Institute  
Technical University of Denmark  
DK-2800 Lyngby, Denmark

For future testing of spacecraft antennas a spherical near-field scanning facility has been developed by the Technical University of Denmark in co-operation with the European Space Agency (ESA)\* (ref. 1).

Spherical near-field testing has at least two advantages over other near-field schemes. The mechanical scanning in the spherical coordinates  $\theta$  and  $\phi$  can very simply be done using standard equipment present in most anechoic chambers, and the far field is obtained in all directions of space. Thus, an absolute calibration of the probe is not needed for the measurement of directivity. As a drawback of spherical near-field testing, mathematical complexity has been mentioned. With the development of the near-field to far-field transformation program SNIFTC complexity is no longer a problem.

One of the main advantages of the spherical scanning system is the fact that it can readily be implemented using standard antenna positioning equipment designed for far-field measurements. In the present facility an antenna tower type 5871A from Scientific-Atlanta is used for rotation of the antenna to be measured (the test antenna) about a horizontal axis. For rotation about the intersecting vertical axis a standard azimuth-positioner could have been used. However, for various reasons a special azimuth positioner was designed for the present facility.

The measuring antenna (probe) is mounted in a fixed, horizontal position with its axis pointing towards the intersection of the horizontal and vertical axes of the antenna tower. The probe is mounted on an absorber-clad probe tower which can be moved back and forth on rails. In this way the radius of the spherical surface on which the test antenna near-field is probed can be varied (fig. 1). The facility is implemented at the TUD anechoic chamber.

The facility makes use of a Scientific-Atlanta model 1774 phase amplitude receiver and a signal source of high stability. The system is a dual channel system permitting simultaneous measurement of two orthogonal polarizations of the test antenna. The probe antenna is a conical horn with a gain of 15 dB at 11.8 GHz. With two channels the measurement time is cut almost by 50%. In addition, measurement of the two polarizations are made in precisely the same points without the need for mechanical rotation of the probe (ref. 2).

Data collecting and controlling is microprocessor based. The microcomputer triggers and reads data from the phase and amplitude displays of the receiver. It also controls the positioning of the test antenna in  $\theta$  and  $\phi$ . Data is stored on magnetic tape for later processing on an IBM 3033 computer. The data processing is done in two FORTRAN packages, SNIFTC for near-field to far-field transformations, and FACSIM for simulation of the influence of

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measurement errors (ref. 3).

As input data SNIFTC uses the signal from the probe antenna ("input probe") and calculates the far field taking probe directivity into account. Both the near field and the computed far field are described in points equispaced in  $\theta$  and  $\phi$  of the spherical coordinate system  $r\theta\phi$ . SNIFTC may also be used to compute the field at a spherical surface with finite radius.

Formally, the output field is calculated as the signal that would be received by some measuring antenna ("output probe") located in the far field or at any other distance where the field is wanted.

SNIFTC is based on the formula for the signal  $W$  received by the probe antenna

$$W(A, \phi, \theta, \chi) = \sum_{smn} Q_{smn} e^{im\phi} c_{\mu m}^n(\theta) e^{i\mu\chi} P_{s\mu n}(A)$$

$$P_{s\mu n}(A) = \frac{1}{2} \sum_{\sigma\nu} C_{\sigma\mu\nu}^{sn}(A) P_{\sigma\mu\nu}$$

In this formula, the  $Q_{smn}$  are spherical wave coefficients of the field radiated by the test antenna with  $s = 1$  for TE waves and  $s = 2$  for TM waves. The rotation coefficients  $e^{im\phi} c_{\mu m}^n(\theta) e^{i\mu\chi}$  and the translation coefficients  $\frac{1}{2} C_{\sigma\mu\nu}^{sn}(A)$  describe the coupling from modes with indices  $smn$  in the test antenna coordinate system to modes with indices  $\sigma\mu\nu$  in the probe system.

The response of the probe to each incoming mode is described by the receiving coefficient  $P_{\sigma\mu\nu}$ . In spherical near-field measurements the signal  $W(A, \phi, \theta, \chi)$  is measured in amplitude and phase on a full sphere with radius  $A$  at points spaced equidistantly in  $\theta$  and  $\phi$ , with two polarization orientations  $\chi = 0^\circ$  and  $\chi = 90^\circ$  applied in each point. From these data, the spherical wave coefficients  $Q_{smn}$  are computed and the far field is found by the equation with  $A = \infty$  and a Hertzian dipole as output probe.

The efficiency and accuracy of SNIFTC has been studied by using a theoretical model (ref. 3). For an antenna with a diameter of 50 wavelength and sampling increments  $\Delta\theta = \Delta\phi = 1$  degree the far field was computed in 65160 points in less than three minutes c.p.u. time. The error was in all points more than 65 dB below the isotropic level.

The spherical near-field scanning facility described has been in operation since April 1979. Results from the first near-field measurements taken at two different distances on a 31 dB reflector antenna are shown in figure 2 and 3. The fact that two rather different near-fields (fig. 2) are transformed into virtually the same far fields (fig. 4) confirms the validity of the method and the accuracy of the facility.

Presently, the facility is being updated for automatic operation using an HP1000 minicomputer for control. This computer will also be used for performing all data reduction and near-field to far-field transformations.

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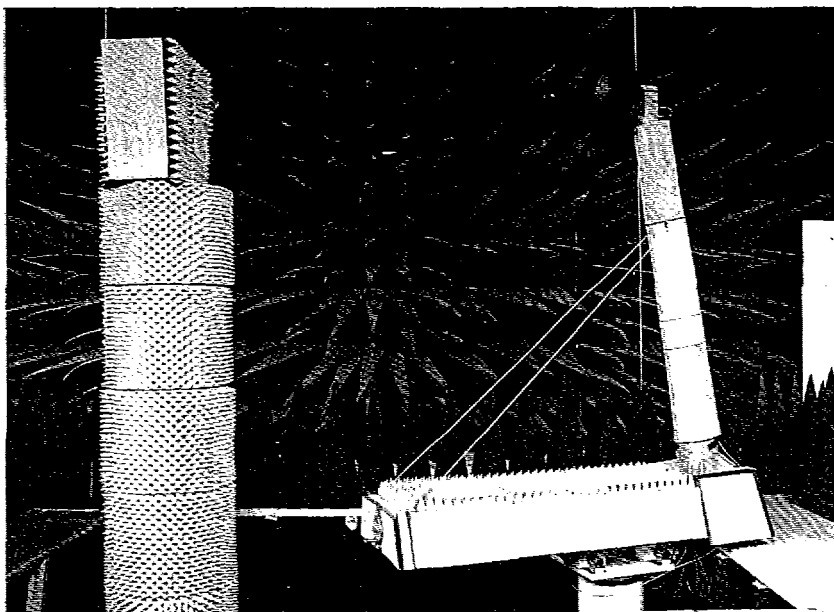


Fig. 1. Probe tower with dual polarized X-band probe at left can be moved on rails (not shown) to provide different radii of the measurement sphere. The measurement sphere is centered at the test antenna (OTS Eurobeam antenna) shown on the antenna positioner at right.

